

SECTIONS OF SOME CARBONIFEROUS DISPERSED SPORES

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ABSTRACT. Sections of microspores, some cingulate, one zonate and one saccate, are discussed and illustrated. It is shown that sections aid the elucidation of wall structures; thus diagnoses can be more precisely written and this may eventually remove some classificatory difficulties. A sectioning technique is described.

WHILE the optical examination of uncompressed spores and pollen can in general lead to a clear morphological interpretation of the wall, most workers have experienced difficulty with strongly compressed spores when there is no comparable living material. Carboniferous microspores with equatorial features have proved most difficult to classify because of morphological misinterpretations which have led to inadequate and uncertain descriptions. The general nature of the wall thickening in some species of such genera as *Densosporites* and *Cirratiradites* has been known for many years from random sections observed in thin sections of coal (Thiessen 1920). These spore sections, many of which have been figured by Stach (1957) from polished coal surfaces, could seldom, however, be assigned to a definite species; in the few cases where specific identity has been established it is unfortunate that their features were not more clearly incorporated in descriptions of spores released by maceration.

It has now proved possible to extend the sectioning method used for megaspores (Hughes 1955, Dettmann 1961) to at least the larger microspores. One of us (M. E. D.) has developed an improved double embedding technique described below.

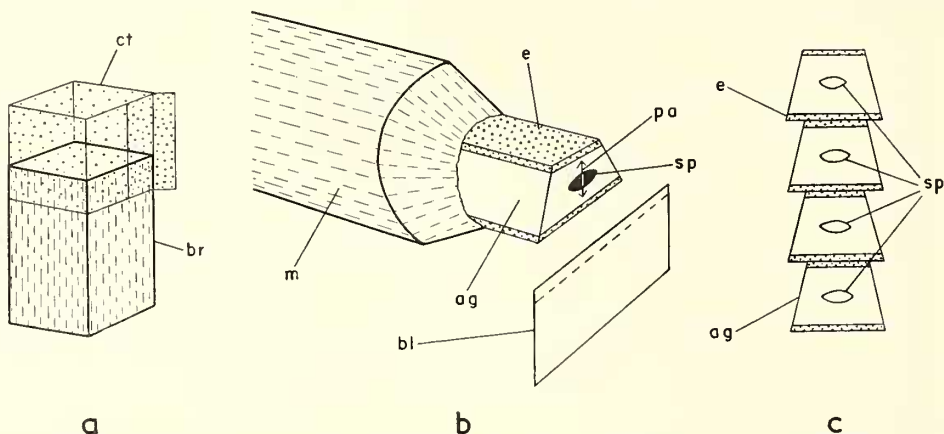
Some of the results in this paper were shown to members at the Krefeld meeting of the 'International Commission for the Microflora of the Palaeozoic' in May 1961, during discussion of the classification of cingulate and zonate spores. They are therefore presented here in systematic order, although obviously a wider selection of material must be sectioned before general conclusions can be reached.

The preparations concerned were all treated with concentrated nitric acid and potassium chlorate (Schulze method). Preparations M928 and M949 were treated for 12 hours, but were only washed in water (no alkali); P164 and P167A were treated for 1½ hours, followed by a single wash in 1 per cent. 'ammonia'; B1702 was cleared in 5 per cent. KOH.

Technique (M.E.D.). The spores which have been sectioned were extracted with a fine camel-hair brush, from glycerine smears of the residues viewed with a binocular microscope at a magnification of 100 diameters. The selected spores were transferred to small porcelain wells (for example, those used for mixing water colours) containing distilled water and were subsequently embedded and sectioned following the techniques of Wigglesworth (1959). An outline of these procedures, in which the spores are double-embedded in agar (Japanese, fine powder) and ester wax (1960 formulation of British Drug Houses Ltd.) before sectioning, is given below.

The individual spores are placed in embedding troughs (as shown in text-fig. 1a) containing 5 per cent. agar solution at 55–60° C. After 10–15 minutes the spore, which sinks

only a short distance below the surface of the agar, is orientated under a binocular so that its equatorial plane lies perpendicular to the surface of the agar. The agar is allowed to cool at room temperature and the block is removed from the trough, trimmed, and passed through the following solutions (standing in each for 30 minutes): ethyl alcohol 30, 50, 70 per cent.; 70 per cent. alcohol plus cellosolve, 2:1; the same, 1:2; pure cellosolve (three changes); cellosolve plus ester wax, equal parts; pure ester wax (two changes). It is then left overnight in ester wax at 55–60° C. After this treatment the block is placed upside down in an embedding trough so that the spore rests near, and with its equatorial



TEXT-FIG. 1. *a*, brass block (7–9 mm. square in cross-section) bound with cellulose tape to form embedding trough; *b*, mounted and trimmed agar block showing position and orientation of spore; *c*, portion of ribbon containing spore sections (Diagram—G. Playford). *ct*, cellulose tape; *br*, brass block; *m*, mount of microtome; *e*, ester; *ag*, agar; *sp*, spore; *pa*, polar axis of spore; *bl*, blade.

plane perpendicular to, the bottom surface of the trough. The trough is then filled with ester wax and cooled rapidly by standing it in a stream of running water.

Prior to sectioning the agar-ester block is mounted and trimmed as shown in text-fig. 1*b*. An end-on view of the resultant block shows narrow strips of ester wax constituting the two sides which parallel the cutting surface of the blade; thus the wax partially sheathes the agar in which the spore is enclosed in its correct orientation. By following this procedure the sections do not readily separate from one another and form a continuous ribbon as shown in text fig. 1*c*. The sections are cut at 1–3 μ intervals transverse to the equatorial plane of the spore, using a razor blade of the 'Pal' or 'Personna' type, mounted on a Cambridge rocking (fine section) microtome. The sections are transferred to glass microscope slides smeared with adhesive albumen, floated out in 20 per cent. alcohol, and dried in an oven at 40–45° C. They are subsequently dewaxed in xylene, immersed briefly in 70, 50, and 30 per cent. alcohol, and finally mounted in glycerine jelly.

All sections are cut at 3–4 μ intervals transverse to the equatorial plane and mounted in glycerine jelly, except those shown in Plate 37, figs. 11 and 12, which are mounted in euparal. The preparations M928 and M949 were made from sample B685, Citadellet; P164 and P167A were from samples G1095 and G1098 respectively, Birger Johnson-fjellet; all from the Lower Carboniferous of Dicksonland, Vestspitsbergen. *Densosporites sphaerotriangularis* was from the Westphalian B of the Beefie seam at 275 feet, Monkton

House B.H., Lothians, Scotland. For each illustrated specimen the preparation and slide number is given. In addition, reference co-ordinates of Leitz Laborlux Microscope no. 1, and registered numbers (prefixed L or M) of the Sedgwick Museum are stated.

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Anteturma SPORITES Potonié 1893
Turma ZONALES (Bennie and Kidston) Potonié 1956
Subturma ZONOTRILETES Waltz 1935
Infraturma CINGULATI Potonié and Klaus 1954
Genus KNOXISPORITES (Potonié and Kremp) Neves 1961
Knoxisporites margarethae Hughes and Playford 1961

Plate 37, figs. 1–5

Discussion. Sections have revealed that the original description was at fault, chiefly in the reconstruction diagram (1961, text-fig. 2*d*). The spore is cingulate and the narrow dark ring (Plate 37, fig. 2) is a refractive effect at the spore cavity limit; the ‘prominent dark ring’ mentioned in the original diagnosis (1961, plate 1, fig. 11) is part of the distal reticulum, which in the holotype happens to be symmetrical. The distal reticulum clearly consists of muri mounted on the distal surface and not raised beyond it as previously suggested. The distal infragranulate appearance is perhaps caused by a slight differentiation of the exine seen in the sections.

Genus ANULATISPORITES Loose ex Potonié and Kremp 1954
Anulatisporites labiatus Hughes and Playford 1961

Plate 37, figs. 9–12

Discussion. We feel that the terminology in current use for this kind of spore (Hughes and Playford 1961, and many others) is undesirable and misleading, particularly in reference to the ‘spore body’ (*Zentralkörper* of Potonié and Kremp 1954). The diagnosis is therefore reworded below to avoid this.

Restated diagnosis. Spore radial, trilete; amb circular to convexly subtriangular; margin entire. Cingulum width approximately half the spore radius; central spore cavity sharply demarcated in polar view. In section cingulum tapers slightly; equatorial margin rounded. Laesurae straight, from half to two-thirds spore radius, with lips; lips 6–10 μ wide with wrinkled outer margins. Exine of proximal and distal areas together appear much thinner than the cingulum in polar view; exine surface laevigate to finely granular.

Restated dimensions (32 specimens). Overall diameter 71–132 μ (mean 102 μ), cavity diameter 42–88 μ (mean 61 μ), cingulum width 12–30 μ (mean 21 μ). Exine thickness, proximal and distal, 6–8 μ .

Remarks. The restated diagnosis should be compared with the original. The concentric zoning often seen on the cingulum is merely due to corrosion, although the pattern of corrosion may well be significant and worth recording. The sections do not show an intexine, the presence of which Smith (1960) has been able to demonstrate in the type species, *A. anulatus*.

Genus *DENSOSPORITES* (Berry) Potonié and Kremp 1954
Densosporites sphaerotriangularis Kosanke 1950

Plate 37, figs. 13–15

Comment. The sections show that the exine consists of a thick exoexine, which envelops the thin intexine and also forms the cingulum; this wall structure was described by Smith (1960) but is not clearly illustrated in his text-fig. 1. The intexine seems to account for the minor folds (Kosanke 1950, p. 33) at the margin of the spore cavity. The translucency of the outer part of the cingulum is due to the abrupt tapering near the equatorial margin. The plicating sheet structure of the cingulum (Kosanke 1950, Smith 1960) is not evident in our sections. It is noteworthy that Kosanke does not use the misleading spore-body terminology.

EXPLANATION OF PLATE 37

All figures from unretouched negatives; magnification, unless otherwise stated, $\times 500$.

Figs. 1–5. *Knoxisporites margarethae* Hughes and Playford 1961. 1, 2, Proximal and distal surfaces of holotype; preparation M928/5 56.8 126.7 (L.889). 3–5, Sections of specimen with one-layered exine showing distal muri and cingulum; prep. M949/S37/1–2. 3, Polar section showing longitudinal and transverse aspect of lips, 28.7 48.4 (L.1259e). 4, 5, Off-polar sections, 36.8 123.6 (L.1259 l) and 32.9 124.9 (L.1259k), showing distal muri cut both transversely and obliquely.

Figs. 6–8. *Cincturasporites auritus* (Waltz) Hacquebard and Barss 1957. 6, 7, Proximal and distal surfaces respectively; prep. P167A/2 45.1 111.4 (L.1260). 8, Section showing one-layered exine, thickened lips and non-tapering cingulum; prep. P167A/S41b 42.5 110.9 (L.1261c).

Figs. 9–12. *Anulatisporites labiatus* Hughes and Playford 1961. 9, 10, Proximal and distal surfaces respectively; prep. M949/8 33.8 121.0 (L.1262). 11, 12, Sections showing one-layered exine and wedge-shaped cingulum. 11, Cut through laesura; prep. M949/S32 34.2 122.2 (L.1263i). 12, Prep. M949/S30 40.8 114.2 (L.1246h).

Figs. 13–15. *Densosporites sphaerotriangularis* Kosanke 1950. 13, Proximal view; prep. B1702/3 38.0 123.0 (M. 5330). 14, 15, Section showing two-layered exine; outer layer (exoexine) forms wedge-shaped cingulum; prep. B1702/S50a 24.9 122.7 (M. 5331e). 15, $\times 1000$.

EXPLANATION OF PLATE 38

All figures from unretouched negatives; magnification, unless otherwise stated, $\times 500$.

Figs. 1–4. *Lophozonotriteles triangulatus* Hughes and Playford 1961. 1, 2, Proximal and distal surfaces respectively; prep. M949/9 34.1 120.8 (L. 1265). 3, 4, Sections of specimen showing one-layered exine, distal sculptural elements and cingulum; prep. M949/S35a. 3, Cut through three distal verrucae, 51.5 127.5 (L.1266f). 4, Showing two distal verrucae, 47.9 126.1 (L.1266e).

Figs. 5–7. *Cirratriadites elegans* (Waltz) Potonié and Kremp 1956. 5, Proximal surface; prep. P164/25 44.5 118.1 (L.1267). 6, 7, Sections showing two-layered exine; exoexine forms 'zona' and lips; prep. P164/S40b/1–2. 6, 40.2 126.7 (L.1268e). 7, $\times 1,000$, 46.3 126.7 (L.1268f).

Figs. 8–10. *Velosporites echinatus* Hughes and Playford 1961. 8, Holotype; prep. M928/1 58.6 118.7 (L.934). 9, 10, Section of compressed specimen showing bladder and body wall; prep. M949/S36b 50.6 120.3 (L.1269m). 10, $\times 1,000$ showing detail of spinose sculpture of body.

